NOTES ON PRACTICE, IMPROVABILITY, AND THE CURVE OF WORK

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Learning and the Curve of Work in the Case of a Clerical Task

Sixty-four educated adults practiced writing the products of 11 x 11, 11 x 12, 12 x 12, 11 x 13, ... 19 x 19 with the aid of a key as shown below.

	11	12	13	14	15	16	17	18	19
11	121	132	143	154	165	176	187	198	209
12	...	144	156	168	180	192	204	216	228
13	...	...	169	182	195	208	221	234	247
14	...	...	...	196	210	224	238	252	266
15	...	...	...	...	225	240	255	270	285
16	...	...	...	...	...	256	272	288	304
17	.....	...	...	...	...	...	289	306	323
18	...	...	...	...	...	...	...	324	342
19	...	...	...	...	...	...	...	...	361

The subject wrote as rapidly as possible the products of 80 pairs of numbers printed in a haphazard order as shown below, using the Key or trusting to memory. The time of beginning and ending and the number of mistakes were recorded. The time record was as exact as the subject could make it, using an ordinary watch with a second hand.

17	19	18	19	11	16	17	17	12	12
12	11	15	18	14	17	12	18	13	14
14	16	16	19	15	19	13	15	14	19
19	11	18	12	16	17	16	12	15	13
18	18	12	13	15	16	18	15	16	11
15	11	17	18	18	14	19	16	18	13
16	18	11	12	13	16	16	13	11	17
13	19	19	18	17	12	14	18	17	14
12	17	15	14	11	13	16	16	13	11

13	13	19	13	14	15	15	17	18	16
18	11	14	11	19	19	16	14	14	14
19	17	11	19	16	15	14	13	15	12
15	15	17	15	19	14	18	17	17	16
19	12	13	18	13	17	12	19	11	14
12	14	14	12	12	15	17	13	13	12
17	11	19	15	11	18	11	15	12	16

Four different sheets, of 80 pairs each, were used in rotation, each one twelve times, making forty-eight sheets done or 3840 entries. The distribution of the practice differed in different groups of subjects, being according to the following scheme:

	Number of sheets done per sitting	Number of sheets done per day	Number of subjects
The 2.2 group	2	2	9
" 2.4 "	2	4	11
" 2.8 "	2	8	10
" 2.8_2 "	2	8 every other day	10
" 8.8 "	8	8	9
" 8.8_2 "	8	8 every other day	15

The practice was preceded and followed by a test with a still different sheet of 50 pairs.

The Nature and Amount of Improvement

The improvement consisted in a mixture of memorizing the products, complete or partial, becoming acquainted with the arrangement of the key and skillful in using it, facility in reading the pairs, facility in entering the products and facility in what may be called "overlapping"—perceiving the next pair and beginning to look at the key or think of the remembered product while entering the product for the previous pair. In no case did the learning progress to complete and perfect memorizing of all the 45 products. No such case was reported, and the shortest times (1.33 sec. and 1.45 sec. per pair) are too long for perfect memorizing.

The improvement is, as would be expected, universal and large. The central tendency is to do twice as much per unit of time and with half as many errors, in the last four sheets of the forty-eight as in the first four. The gain from the preliminary test with 50 pairs to the final test is still greater.

The Effect of the Distribution of Time Upon Improvement

In order to compare the effect of the different distributions of practice it is necessary to equalize the initial ability of the groups by subtracting one or more cases. When this is done,

we have, as average scores with the first four sheets, average scores with the last four sheets, average gross gains and average corrected gains, the following:

	Average score with sheets 1-4		Average score with sheets 45-48		Average gross gain		Average corrected gain, counting each error as 10 seconds
	Secs.	Er'rs.	Secs.	Er'rs.	Secs.	Er'rs.	
2.2 (n 9)	1506	4.66	733	2.00	773	2.66	800
2.4 (n 10)	1531	4.10	750	3.20	781	.90	790
2.8 (n 7)	1523	3.57	809	3.57	714	00	714
2.8_2 (n 8)	1478	7.75	814	1.88	664	5.87	723
8.8 (n 9)	1492	8.22	764	3.22	728	5.00	778
8.8_2 (n 15)	1517	4.13	760	2.40	757	1.73	774

Taking these results at their face value, they show (1) that when 8 sheets are done daily or every other day, they are more profitably done 8 at a sitting than 2 at a sitting, (2) that whether practice is daily or every other day makes little or no difference in the improvement per unit of time spent, and (3) that whether practice is spread over 24 days or consolidated into 6 makes little difference provided the long day's work is done at one sitting.

The individual differences in improvement are, however, very large and the correction for errors is rather arbitrary, so that the quantities should be considered in combination with similar quantities found in other studies rather than alone. So considered, they seem to support the doctrine that in such minor clerical tasks as adding, substitution tests, hunting for items and the like, there is little or no advantage in very short periods of learning, but is some advantage in fairly long intervals between practice, other things being equal.

Individual Differences in Improvement

Individual differences in improvement are large. The extremes for the total group are represented by (1) individual H. G. C., who worked the first four sheets of the forty-eight at a rate of 18.7 pairs per minute, and the last five sheets at a rate of 45.0 pairs per minute, spending in all 6967 sec., or 6237 sec. from the mid-point of the first four to the mid-point of the last four, and (2) individual Whi., who worked the first four at a rate of 7.93 pairs per minute, and the fourth four at a rate of 9.6 pairs per minute, spending so far 8440 sec., or 6230 sec. from the mid-point of the first four to the mid-point of the fourth four. The use of the four sheets' average is a little unfair to Whi., but this is balanced by the

fact that his errors increased from 0 to 9 whereas those of H. G. C. decreased from 3 to 1. H. G. C. and Whi. then, from equal amounts of time given to practice, made gains of 26.3 and 1.7 respectively, in the product produced per unit of time.

The rate of gross gain in the product produced per unit of time is, as I have elsewhere shown, positively correlated with initial ability.

The facts for groups of high and low initial ability are shown below.

	Average number of minutes from beginning to end of the practice measured here	Average number of pairs per minute in 4 sheets	Average number of pairs per minute in 4 sheets done after about 122 minutes of practice (from mid-point to mid-point)	Gain in pairs per minute	Average number of errors in first four	Average number of errors in late four
8 initially highest individuals.....	134½	19.4	34.6	15.2	3.38	4.63
4 initially next highest individuals...	146	16.3	29.9(131 min.)	13.6	5.5	2.8
7 initially next to lowest individuals.	161	11.4	20.8(133 min.)	9.4	5.14	3.71
5 initially lowest individuals.....	155½	7.87	12.56	4.7	8.5	5.6

The effect of equalizing opportunity is thus to increase individual differences. This result, now found with many different functions, furnishes perhaps the strongest argument in support of the view that differences in achievement are largely due to differences in original capacity.

The correlation between initial ability and improvement is, of course, not perfect, fairly large differences in the latter being found amongst those of equal initial scores. Thus Br. and H. G. C., beginning at 18.5 and 18.6 pairs per minute respectively, gained 13.5 and 26.3, though the former spent more time than the latter. Thus Me. and Ch., beginning at 16.6 and 16.3, gained 7.0 and 20.8 respectively, though the former spent much more time than the latter.

Changes in the Rate of Improvement

The form of the practice curves in so short an experiment as this is not of much theoretical importance. It is in general

of a type beginning with notable negative acceleration and passing thence into an approximately straight line, the form being roughly as in Fig. 1.

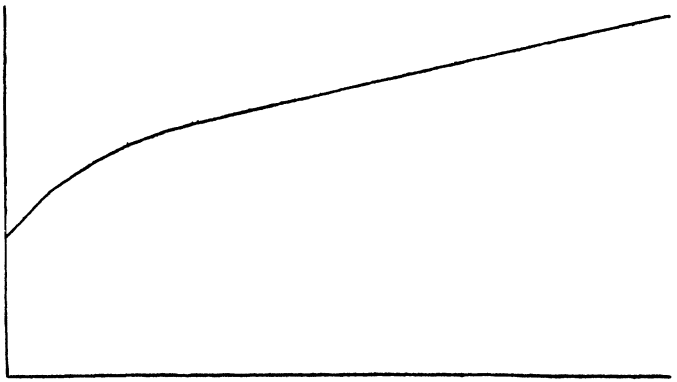

FIG 1.—The approximate form of the curve of practice in recording the products of pairs of numbers from a key.

THE CORRELATION BETWEEN SPEED AND ACCURACY

The total time spent and the total number of wrong products entered for each individual in 12 selected sheets are shown in Table I. This correlation table shows that there is a positive relation, and that in particular, no one of the twelve most rapid workers was amongst the dozen or so most inaccurate workers. The correlation between speed and accuracy by the formula $r = \text{cosine } \pi U$ where U is the estimated percentage of the unlike-signed pairs, is somewhat over $+.4$.

THE CURVE OF WORK

We may use the records for those individuals who did eight sheets at a sitting for an analysis of the curve of work. In this I have utilized only the records of the last thirty-six or twenty-four sheets, so as to examine the function after it is well established.

When no allowance for errors is made, the average time required for the successive sheets of a sitting stood in the following relation: 108.3, 104.1, 99.5, 101.3, 98.7, 98.2, 96.2, 93.8. The P. E.'s (or median probable divergences of these quantities from the similar quantities obtained from an infinite number of similar experiments) are, in order: 1.5, 1.9, .9, .5, .5, 1.3, 1.3, .8. When 10 seconds is added for each

TABLE I

Correlation Between Speed and Accuracy

Time required for 960 products: In minutes: 39 = 39.0 to 41.0, 41 = 41.0 to 43.0, etc.

Errors made in 960 products	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93
1– 3	..	..	..	1	..	..	..	1	..	1	1	..	1	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..
4– 6	..	..	1	..	..	1	1	1	1	3	1	..	1	..	..	1	2	..	..	..	..	..	..	1	..	..	..	1
7– 9	..	..	1	..	1	2	1	2	..	2	1	2	1	..	1	..	1	..	..	1	..	..	..	..	..	..	..	..
10–12	..	..	..	..	..	..	..	2	1	4	..	1	..	2	2	1	..	..	1	..	..	..	..	..	..	..	..	..
13–15	1	..	..	1	1	1	1	1	2	..	..	2	..	1	4	3	..	..	1	..	1	..	..	1	..	..	..	..
16–18	..	..	..	1	..	..	1	1	..	1	1	..	2	1	1	..	1	..	..	..	..	..	..	..	..	..	..	..
19–21	..	..	..	..	..	..	2	1	..	..	..	1	2	1	..	..	..	..	..	1	..	1	1	..	..	..	..	..
22–24	..	..	..	..	1	..	..	1	1	..	2	..	1	1	2	..	..	..	..	1	..	..	..	..	..	..	..	..
25–27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	..	1	..	..	..	..	..	..	..	..	..
28–30	..	..	..	..	..	..	1	..	..	..	..	..	1	..	1	..	..	2	..	..	..	..	..	..	..	..	..	..
31–33	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
34–36	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
37–39	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
40–42	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
43–45	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..
46–48	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
49–51	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..
52–54	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
55–57	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
58–61	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..

error the average corrected times for the successive sheets of a sitting are in the relation: 107.8, 103.4, 98.4, 100.8, 99.1, 96.9, 96.7, 93.8. The P. E.'s for these quantities are, in order: 2.2, 2.2, 1.5, .5, .6, .9, 1.1, 1.3. In terms of product produced per unit of time these quantities appear as in Fig. 2 and Fig. 3.

There is thus no evidence of "initial spurt" and very slight evidence of "end spurt." The case is no different if only those individuals who took three minutes or less per sheet are used. The curve of work is substantially a section of the latter part of the general curve of learning plus perhaps a slight "warming up" effect and a still slighter "end spurt." The irregularities toward the middle of the curve are, in my opinion, most probably a matter of accidental variation.

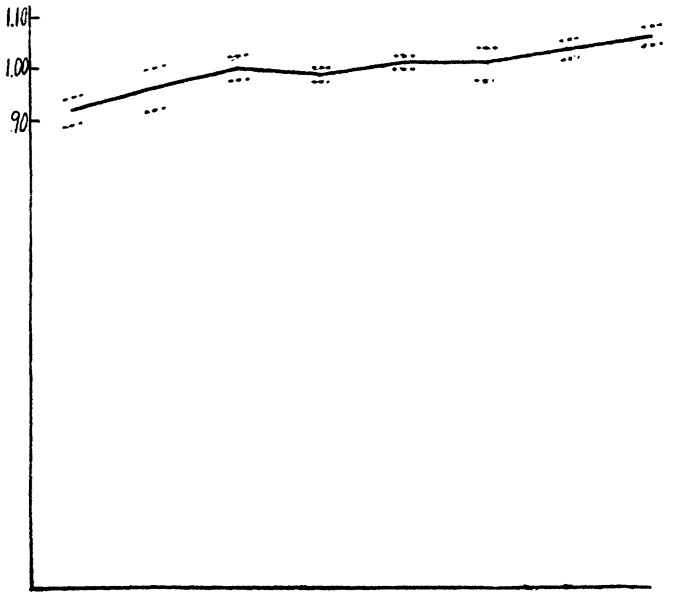

FIG. 2.—The curve of work for recording the products of pairs of numbers from a key. Equal lengths along the abscissa represent equal numbers of sheets done. The height of the continuous line represents the time required, as a multiple of the average time required for sheets IV and V. The dotted lines are at a distance from the continuous line equal to 2 P.E.

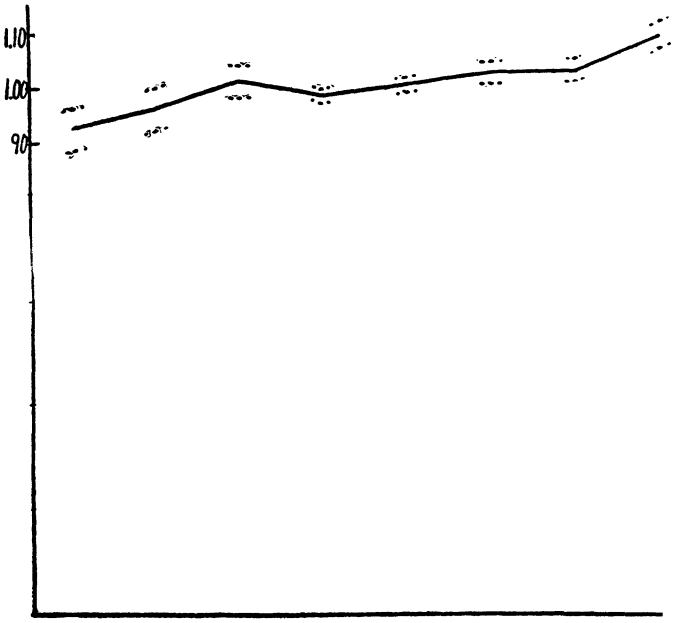

FIG. 3.—Same as Fig. 2 except that an addition of 10 sec. for each error is made.

The Correlations Between Initial Ability and Improvement and Between Improvement and One Function and Improvement in Other Functions.

Fifteen college students practiced on each of five days for each of two weeks at checking numbers on the Woodworth-Wells blank, adding columns of figures, multiplying mentally with two three-place numbers after the method used previously by the author, and typewriting. The details concerning the length of periods, the conditions of practice and the like need not be reported here. They were free from anything prejudicial to the conclusions to be stated here.[1]

The data used are shown in Table II. The six lines reported for each individual concern the results in canceling 2's

[1] The practice occurred in connection with the work of the New York State Commission on Ventilation made possible by the Anderson foundation, was planned by the author and was carried on under the immediate direction of Mr. W. A. McCall. For the computations required for this article the author is responsible. Full details concerning the experiments may be found in VENTILATION IN RELATION TO MENTAL WORK by Thorndike, McCall and Chapman, New York, 1916.

(first line), canceling 3's (second line), addition (third line), mental multiplication (fourth line), and typewriting (first ten minutes in the fifth line and second ten minutes in the sixth line). The figure under 'Average' in the case of line 6 is, however, in each case, the *median* of the four scores of lines 5 and 6.

TABLE II

INITIAL AND FINAL SCORES OF 15 INDIVIDUALS

		Day 1			Day 10			Gain in Day 1 to Day 10
		Trial 1	Trial 2	Average	Trial 1	Trial 2	Average	
Brdd....	2's...	134	146	140	174	166	170	30
	3's...	150	152	151	186	176	181	30
	Add.	94	113	104	151	149	150	46
	Mult.	50	68	59	100	98	99	40
	Typ.	155	166		222	205		
		132	158	157	219	183	212	55
Ferg.	2's...	132	134	133	164	162	163	30
	3's...	132	132	132	158	162	160	28
	Add.	62	79	71	122	131	127	56
	Mult.	44	37	41	90	86	88	49
	Typ.	61	77		141	144		
		78	82	78	133	151	143	65
Leik.	2's...	120	130	125	154	156	155	30
	3's...	142	138	140	180	156	168	28
	Add.	63	69	66	95	99	97	31
	Mult.	69	122	96	173	143	158	62
	Typ.	80	89		150	141		
		80	95	85	153	145	148	63
Levy....	2's...	94	110	102	136	154	145	43
	3's...	98	124	111	148	142	145	34
	Add.	40	44	42	60	70	65	23
	Mult.	31	57	44	109	113	111	67
	Typ.	71	86		141	124		
		77	92	82	145	135	138	56
Bost....	2's...	104	106	105	200	196	198	93
	3's...	124	124	124	176	176	176	52
	Add.	38	43	41	58	67	63	22
	Mult.	68	96	82	282	279	281	199
	Typ.	120	147		240	237		
		128	139	134	220	206	229	95
Elle.....	2's...	108	108	108	195	202	199	91
	3's...	108	118	113	143	166	155	42
	Add.	74	75	75	123	105	114	39
	Mult.	67	80	74	226	250	238	164
	Typ.	205	189		242	230		
		198	191	195	223	229	230	35

TABLE II—*Continued*

INITIAL AND FINAL SCORES OF 15 INDIVIDUALS

		Day 1			Day 10			Gain in Day 1 to Day 10
		Trial 1	Trial 2	Average	Trial 1	Trial 2	Average	
Solo. . . .	2's. . .	134	140	137	190	198	194	57
	3's. . .	144	150	147	196	182	189	42
	Add.	63	68	66	122	113	118	52
	Mult.	89	113	101	161	164	163	62
	Typ.	59	114		170	160		
		104	130	109	177	195	174	65
Kuen . . .	2's. . .	110	112	111	152	158	155	44
	3's. . .	122	126	124	138	142	140	16
	Add.	53	50	52	97	108	103	51
	Mult.	82	80	81	192	188	190	109
	Typ.	76	86		139	133		
		75	80	78	126	137	135	57
Rivl. . . .	2's. . .	118	122	120	184	188	186	66
	3's. . .	138	136	137	172	168	170	33
	Add.	49	44	47	106	114	110	63
	Mult.	40	47	44	179	200	190	146
	Typ.	95	118		155	161		
		101	123	110	153	174	158	48
Stac. . . .	2's. . .	88	106	97	154	166	160	63
	3's. . .	126	128	127	162	164	163	36
	Add.	79	88	84	128	124	126	42
	Mult.	65	82	74	218	212	215	141
	Typ.	39	53		125	147		
		50	66	52	125	145	135	83
Zuck. . . .	2's. . .	104	114	109	140	160	150	41
	3's. . .	122	126	124	160	152	156	32
	Add.	53	59	56	113	110	112	56
	Mult.	71	107	89	323	342	333	244
	Typ.	84	86		162	169		
		71	85	85	160	165	164	79

Except in the case of typewriting, the gain in product produced per unit of time is a little greater for those of initially high ability. In typewriting, the opposite is the case. This is what would be expected in view of the form of the curve of practice in typewriting, and the fact that the amount of practice one has had in it is largely independent of his ability.

The data of Table I give some information concerning the relation of ability to improve in one mental function to ability to improve in other functions. The correlations by the formula $r = 2 \sin\left(\frac{\pi}{6}\rho\right)$ where $\rho = 1 - \frac{6\xi D^2}{N(n^2-1)}$ are:

Gain in canceling with gain in adding.....r =.10
" " " " " " mental multiplication.....r =.29
" " " " " " typewriting.....r =.10
" " adding with gain in mental multiplication.....r =.25
" " " " " " typewriting.....r =.12
" " mental multiplication with gain in typewriting...r =.07

These correlations are subject to attenuation but not to any large extent, the correlation between the gain in canceling 2's and the gain in canceling 3's being .77, that between the gain in addition (trial 1) and gain in addition (trial 2) being .84, that between gain in mental multiplication (trial 1) and between gain in mental multiplication (trial 2) being .81, and that between gain in typewriting (first period) and typewriting (second period) being .80. It is unlikely that these 15 subjects would then with perfect measures of gain show correlations over 20% higher than the raw correlations given above. We may estimate these corrected coefficients as:

Gain in canceling with gain in adding.....r =.12
" " " " " " mental multiplication.....r =.35
" " " " " " typewriting.....r =.12
" " adding with gain in mental multiplication.....r =.30
" " " " " " typewriting.....r =.14
" " mental multiplication with gain in typewriting...r =.09

The probable errors due to the small number of cases are of course large, approximating .15, but it must be remembered that further cases would be as likely to decrease as increase the correlations.

The capacity to learn thus appears to be specialized in much the same way as the abilities found at any stage of learning. The lack of correlation found among the latter is not the result chiefly of differences in the relative amounts of practice which they have had, but is in very large measure more fundamental, due to characteristics of the person's original nature.

The Effects of a Day of Study and a Night of Rest Upon the Ability to Read

It is desirable to repeat the experiments that have been made upon the effects of work and rest, using ordinary tasks instead of the special work in computation, memorizing and the like, which, tho convenient for measurement, may be specially stimulating by its novelty or by the obviousness of its standards of achievement.

As one such experiment, I have used the task of reading a paragraph and answering questions about it. Twelve para-

graphs, N, O, P, Q, R, S, T, V, W, X, Y and Z, were used, Z being shown here as a sample. They differed in difficulty, some being much harder than Z; and some, easier. Twelve individuals read these paragraphs and answered these questions, beginning work at or near 8 P. M., doing ten as a continuous task, and doing two more the next forenoon after a full night's rest. One individual did them in the order, N, O. P. Q, etc.; another in the order O, P, Q, R, etc.; another in the order P, Q, R, S, etc., so that each paragraph was done as the first, the second, ... the twelfth.

Z

Write your name here .....

Read this paragraph and then write the answers to questions 1, 2, 3 and 4. Read it again as often as you need to.

Certain anthropologists have been led to the conclusion that the types of human culture represent an evolutionary series; that the primitive tribes of our times represent an older stage of cultural development through which the more advanced types passed in earlier periods. An important theoretical consideration has shaken our faith in the correctness of the evolutionary theory as a whole. It is one of the essential traits of this theory that, in general, civilization has developed from simple forms to complex forms, and that extended fields of human culture have developed under more or less rationalistic impulses. Of late years we are beginning to recognize that human culture does not always develop from the simple to the complex, but that in many aspects two tendencies intercross,—one from the complex to the simple, the other from the simple to the complex. It is obvious that the history of industrial development is almost throughout that of increasing complexity. On the other hand, human activities that do not depend upon reasoning do not show a similar type of evolution. It is perhaps easiest to make this clear by the example of language, which in many respects is one of the most important evidences of the history of human development. Primitive languages are, on the whole, complex. Minute differences in point of view are given expression by means of grammatical forms; and the grammatical categories of Latin, and still more those of modern English, seem crude when compared to the complexity of psychological or logical forms which primitive languages recognize, but which in our speech are disregarded entirely. On the whole, the development of languages seems to be such that the nicer distinctions are

eliminated, although it must be acknowledged that opposite tendencies are not by any means absent.

1. In what feature is the development of man's work with tools contrasted with the development of his work with words? .....

   .....

2. According to the doctrine that the different ways of living of different tribes of men form a progressive developmental series, what is the relation of simplicity and complexity to the temporal order of this developmental series? .....

   .....

3. What principle of development is almost universally characteristic of the history of industry for the past ten thousand years or more? .....

   .....

4. In what feature of civilization do primitive tribes seem to show greater elaborateness and delicacy of distinctions than modern Europeans? .....

   .....

The time spent, the wrong answers given and a rough estimate of the satisfyingness of the work in each period, were recorded. 5 was used for an ordinary condition of enjoyment of work; 10, for the maximum of satisfyingness that an individual had ever experienced; 0, for the extreme of distaste and wretchedness.

The total times (in minutes), errors, correct responses, and reported satisfyingness at each period were as follows:

EVENING AFTER WORK

Period	1	2	3	4	5
Time	211.0	150.3	133.6	143.5	142.3
Errors	14	16	20	8	15
Correct responses	51	49	45	57	50
Satisfyingness	69	72.5	69	74	71.5
Period	6	7	8	9	10
Time	160.5	131.5	137.5	163.5	160.0
Errors	17	15	17	10	16
Correct responses	48	50	48	55	49
Satisfyingness	68.5	69.5	68.5	68	64.5

	NEXT DAY, AFTER REST	
Period	11	12
Time	129.0	117.3
Errors	17	14
Correct responses	48	51
Satisfyingness	77.5	75.5

The time for the first paragraph read is long, the individual adapting himself to the task and being specially cautious. After that the times increase slightly. If we call the average time for periods 2, 3, and 4, 100, that for periods 5, 6 and 7 is 101.6; and that for periods 8, 9 and 10 is 105.4. After the rest the time falls, being 84.5 on the basis of 100 for periods 2, 3 and 4. How much of these differences is to be credited to the eyes and how much to the central nervous system, remains a question. It is the writer's opinion that the major share belongs to the former. The quality of the work remains closely the same throughout, the errors for periods 2, 3 and 4 being 44; those for periods 5, 6 and 7 being 47; those for periods 8, 9 and 10 being 43; and those for periods 11 and 12 after rest being 31 (or 46½ on a just basis of comparison). The satisfyingness falls off as work progresses and increases sharply after rest. The average degree of satisfyingness in periods 2, 3 and 4 was 6.0; in periods 5, 6 and 7 it was 5.8; in periods 8, 9 and 10 it was 5.6; after rest it was 6.4.

The Effect of Rests Upon Achievement and Improvement in Difficult Mental Work

The form of work used in the experiments to be reported here was the mental multiplication of a three-place number by a two-place number, 1's or 0's being excluded from the digits of the numbers. The numbers themselves were visible throughout the multiplication. Five such examples were done without any pause save that required to write the answer, note the time at which it was written and record it. At the end of such a series of five, another series was begun either (a) at once, or (b) after 10 minutes of rest, or (c) after 20 minutes of rest. This, continued for five series or 25 examples, made one day's task. The score was the time for each example plus one-fifth of the time for each wrong figure in the answer. This was understood by the subjects and they were instructed to work for the best attainable score.

The subjects were divided into three squads, each of which did 25 examples on each of three consecutive days and 5 examples in the morning of the fourth day. Squad 1 (11 individuals) worked the first day with 0 rests, the second day

with 10-minute rests and the third day with 20-minute rests. Squad 2 (7 individuals) worked the first day with 10-minute rests, the second day with 20-minute rests, and the third day with 0 rests. Squad 3 (8 individuals) worked the first day with 20-minute rests, the second day with 0 rests and the third day with 10-minute rests.

To prevent the very slow individuals from having undue weight in determining the conclusions, I have expressed each individual's scores as a per cent of his average score for the entire sixteen series (of 5 examples each). When this is done and the results for each squad are averaged, we have the following results:

	Day 1					Day 2					Day 3					Day 4
Squad 1	153	140	145	151	113	99	97	92	84	76	71	73	90	83	84	61
Squad 2	140	128	127	126	109	94	99	97	88	95	82	83	91	82	84	76
Squad 3	163	145	129	138	97	102	104	100	89	87	87	82	73	71	69	62

When the gains are put in relation to the length of the rest periods, the results, as shown below, favor slightly the 10-minute rest periods, both in immediate achievement and in the effect as it remains over twenty-four hours. It would be of interest to discover whether the 10-minute periods would be equally effective if filled with some other variety of work. The difference over 0 rest is not sufficient to justify the rests as periods of inactivity in practice.

GAINS FROM THE FIRST TO THE FIFTH SERIES OF THE SAME DAY

	Day 1	Day 2	Day 3	Sum
With 0 rests.....	40	15	—2	53
" 10′ "	31	23	18	72
" 20′ "	66	—1	—13	52

GAINS FROM THE FIRST SERIES OF ONE DAY TO THE FIRST SERIES OF THE FOLLOWING DAY

	Day 1 to 2	Day 2 to 3	Day 3 to 4	Sum
With 0 rests.....	54	15	6	75
" 10′ "	46	28	15	89
" 20′ "	61	12	10	83

It may be noted that the average curve of the work of all three squads shows substantially no effect of the 24-hour intervals. Those intervals, under the conditions of the experiment, in which they were filled by the student's ordinary activities and sleep, did as much good as they did harm by the remission of the special activity. The final day's test, either because of

the special rest before it, or because of the facilitation due to knowledge that it was the last of the series, or for both causes, was much better than the last series of the day before.[2]

The results of this experiment are consistent with all similar experiments in showing a very rapid improvement in the special function concerned, such as could not occur if the chief element in the efficiency of the function were a general power of 'concentration' which the previous lives of the subjects had improved *in toto*.

The experiments give useful data concerning initial spurt—a general tendency to maintain for a minute or so a rate of achievement which is soon abandoned. I have compared the scores for the first, second and third examples in a series after rest in the case of the eight most rapid workers, the result being an average time of 77 sec. with .426 wrong figures for the first, 94 sec. and .603 wrong for the second and 82 sec. and .441 wrong figures for the third. With six individuals who required two to three minutes per example, the averages for the first, second and third examples of a series after rest were, respectively, 128 sec. with .68 wrong figures, 138 sec. with .84 wrong figures and 141 sec. with .84 wrong figures. The superiority of the work of the first minute or two is not surely due to a general tendency to initial spurt, since a part of the difficulty of this mental multiplication is the confusion of the numbers with memories persevering from previous examples, a form of interference from which the first example of a series is obviously relatively free. In general, I have failed to find evidence of initial spurt in mental work.

[2] 152, 138, 134, 138, 106, interval, 98, 100, 100, 84, 86, interval, 80, 79, 85, 79, 79, special interval, 66.